

**HAZARDOUS  
MATERIALS SHIPPING:**  
DOT TRAINING, PART 2

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**OUTLINE - PART 2**

- Emergency Response Information
- Contamination Limits/Radiation Level Limits
- Placards
- Security and Safety Plans
- Incident Reporting
- Package Receipt
- Practical Application
- Conclusion
- Sample Questions

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**EMERGENCY RESPONSE  
INFORMATION**

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**EMERGENCY RESPONSE INFORMATION**  
(§172.600)

- Must:
  - Be printed legibly in English
  - Be immediately available/accessible for use at all times the hazardous material is present (away from the package containing the hazmat)
  - Include an emergency response phone number that is:
    - Monitored at all times and immediately connects a responder to a knowledgeable individual (or has immediate access to a knowledgeable individual)
    - Answering services, machines, etc., that require a call-back will not meet requirements
  - Printed prominently on the shipping paper
- May be on the shipping paper or in a supplemental document
- Does not apply to hazardous materials excepted from shipping paper requirements

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**EMERGENCY RESPONSE INFORMATION**  
(§172.600)

- Must include:
  - Basic description and technical name
  - Immediate hazards to health
  - Risks of fire or explosion
  - Immediate precautions in the event of accident or incident
  - Immediate methods for handling fires
  - Initial methods for handling spills or leaks in the absence of fire
  - Preliminary first aid measures
- May also refer to *Emergency Response Guidebook*, specific page (published by DOT)

HAZARDOUS SAFETY DATA SHEET	
UNCLAS: 60-08	PLUM: ALL SCALBLE
<b>PHYSICAL CHARACTERISTICS:</b>	
HAZARDOUS: 071-000	TYPE: 000000 000000
HAZARDOUS: 071-000	HAZARDOUS: 071-000
HAZARDOUS: 071-000	HAZARDOUS: 071-000
HAZARDOUS: 071-000	HAZARDOUS: 071-000
<b>EXTERNAL RADIATION HAZARDS AND SHIELDS:</b>	
The external dose rate at 1 m (3 ft) is 0.01 mSv/hr (0.001 R/hr) at 1 m (3 ft) from the surface of the container. A 10 mCi gamma source is contained in a 1 m (3 ft) diameter shielded container. The external dose rate at 1 m (3 ft) is 0.01 mSv/hr (0.001 R/hr) at 1 m (3 ft) from the surface of the container.	
<b>HAZARDOUS IF INTERNALLY EXPOSED:</b>	
The annual limit of intake (ALI) of radionuclides in a whole-body gamma exposure is 5000 MBq (135 mCi) for radionuclides with a half-life of 100 days or less.	
<b>DOSEMETRY AND BIOASSAY REQUIREMENTS:</b>	
For transport and shipment, high level (HL) and intermediate level (IL) materials are handled. Other sources may be required after spills or contamination incidents.	
<b>SPECIAL PROBLEMS AND PRECAUTIONS:</b>	
1. Shield before hot drilling. Remove promptly. Handle with extreme care in areas of hot spots or thermal. Change gloves often.	
2. High-level waste is those with half-life greater than 90 days.	

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**CONTAMINATION LIMITS**  
**RADIATION LEVEL LIMITS**

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**NON-FIXED EXTERNAL RADIOACTIVE  
CONTAMINATION LIMITS (§173.443)**

Contaminant	Maximum permissible limits		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
Beta, gamma and low toxicity alphas	4	10 <sup>-4</sup>	240
All other alphas	0.4	10 <sup>-5</sup>	24

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**NON-FIXED EXTERNAL RADIOACTIVE  
CONTAMINATION LIMITS (§173.443)**

- Must be ALARA and meet maximum permissible limit
- Area wipe of 300 cm<sup>2</sup> using moderate pressure
- Measure activity on wipe using appropriate method

$$\text{Activity} = \frac{\text{Radioactivity detected on wipe}}{\text{Surface area wiped} \times \text{detection efficiency} \times \text{wipe efficiency}}$$

- Actual wipe efficiency may be used OR may assume to be 10%

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**NON-FIXED EXTERNAL RADIOACTIVE  
CONTAMINATION LIMITS (§173.443)**

- Example:
  - I-131
  - Area wiped = 300 cm<sup>2</sup>
  - Assess wipes using pancake GM with an efficiency of 20% with NET result of 100 cpm
  - Wipe efficiency of 10%
  - Limit for I-131 = 240 dpm/cm<sup>2</sup>

$$\text{dpm} = \frac{100 \text{ cpm}}{300 \text{ cm}^2 \times 0.2 \text{ cpm/dpm} \times 0.1} = 16.7 \text{ dpm/cm}^2$$


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### RADIATION LEVEL LIMITS (§173.441)

- Under normal shipping conditions:
  - Radiation levels at surface of package may not exceed 2 mSv/h (200 mrem/h)
  - TI may not exceed 10
  - Yellow III
- If radiation level limits are exceeded:
  - Package must be shipped EXCLUSIVE USE
    - Radiation levels at surface of package may not exceed 2 mSv/h (200 mrem/h) unless CLOSED VEHICLE requirements with limit of 10 mSv/h (1000 mrem/h)
    - Radiation levels on outside of vehicle may not exceed 2 mSv/h (200 mrem/h)
    - Radiation levels at any point 2 m (6.6 ft) from outer lateral surfaces of vehicle may not exceed 0.1 mSv/h (10 mrem/h)
- If EXCLUSIVE USE/CLOSED VEHICLE exceptions are used, offeror must provide specific written instructions for maintenance of exclusive use shipment controls
- Conveyance limits:
  - Sum of TIs ≤ 50 (except cargo aircraft/sea-going vessel)
  - No limit for EXCLUSIVE USE
  - Follow regs for shipments by air/vessel (§§175.700 – 175.705; 176.700 – 176.720)
- Packages with surface radiation level > 2 mSv/h (200 mrem/h) or TI > 10 may not be transported by aircraft




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### PLACARDS

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### PLACARDS (§172.504, 507, 516, 556)

- Required for:
  - Radioactive YELLOW-III
  - Unpackaged LSA-I or SCO-I
  - Exclusive Use shipment
  - Closed Vehicle shipments
  - HRCQ
- Must have Commercial Driver's License (California requires Hazardous Materials Endorsement to CDL)




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## PLACARDS

- Placards must be:
  - Visible from each direction
  - Securely attached/affixed or in a holder
  - Located clear of any other items/devices
  - Located away from any marking that could reduce effectiveness
  - Have writing displayed horizontally reading left to right
  - Be maintained so format, legibility, color, visibility is not impaired
  - Affixed to a background of contrasting color or have an outer border which contrasts with background color
  - At least 250 mm (9.84") on each side, etc.

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## PLACARDS (§172.556)

21 Except for size and color, the RADIOACTIVE placard must be as follows:



22 In addition to complying with §172.516, the background color on the RADIOACTIVE placard must be white in the lower portion with a yellow triangle in the upper portion.

23 In addition to complying with §172.516, the background color on the RADIOACTIVE placard must be white in the lower portion with a yellow triangle in the upper portion. The base of the yellow triangle must be 20 mm (0.79 inches) and 2 inches (5.1 inches) above the placard horizontal center line. The symbol, text, class number and outer border must be black.

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## SAFETY AND SECURITY PLANS

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**SAFETY AND SECURITY PLANS**  
(§172.800, 802)

- Each person that offers for transportation or transports HRCQ of radionuclides must develop and adhere to a transportation security plan
- Plan must include:
  - Assessment of security risks
  - Personnel security – measures to confirm information provided by job applicants
  - Unauthorized access – measures to address risk that unauthorized persons may gain access to materials
  - En route security – measures to address security risks of shipments en route
  - Identification by job title of the senior management official responsible for development and implementation of plan
  - Security duties for each position or department including process of notifying employees when specific elements of plan have been implemented
  - Plan for training hazmat employees

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**SAFETY AND SECURITY PLANS**  
(§172.800, 802)

- The Plan:
  - Must be in writing and retained as long as it remains in effect
  - Reviewed annually and revised and/or updated as necessary
  - Most recent version must be available to employees who implement it consistent with security clearance or background investigation restrictions and a demonstrated need to know
  - Re-training of all employees when security plan is updated or revised
  - Each person who must develop and implement the plan must maintain a copy of it that is accessible at, or through, the principal place of business and must make it available upon request to an authorized official of the DOT or DHS.
- A security plan used to satisfy requirements of 10CFR37 may be used to satisfy requirements if all items are addressed

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**INCIDENT REPORTING**

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**INCIDENT REPORTING**  
(§171.15, 171.16)

- Immediate Notification (phone or on-line)
  - National Response Center
  - ASAP and ≤ 12 hours after event
  - Event occurs during transportation in commerce (including loading, unloading, temporary storage)
  - As a direct result of hazardous material:
    - Person is killed
    - Person receives injury requiring hospitalization
    - General public is evacuated for one hour or more
    - Major transportation artery or facility is closed or shut down for one hour or more
    - Operational flight pattern or routine of an aircraft is altered
  - Fire, breakage, spillage or suspected radioactive contamination occurs
  - Etc.
    - Infectious material, marine pollutant, event that seems like it should be reported (even if it doesn't meet criteria); fire, etc., during aircraft transport of battery or battery powered device

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**INCIDENT REPORTING**  
(§171.15, 171.16)

- Written Report
  - Use Hazardous Material Incident Report on DOT Form F 5800.1
  - Within 30 days
  - Any of the events requiring immediate notification
  - Any unintentional release of hazardous material
  - Specification cargo tank receives damage requiring repair
  - Undeclared hazmat is discovered
  - Fire, violent rupture, explosion, etc., that occurs as the result of a battery or battery-powered device (not only on aircraft)
- Update to report must be made within one year if there is a death from injury caused by hazmat; misidentification of the hazmat or package info; damage, loss or related cost not known initially
- Damage, loss, related cost changes by more than \$25K or 10% of prior total estimate
- Exception to reporting requirements for small quantities of materials, etc., but not for radioactive materials

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**PACKAGE RECEIPT**

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**PACKAGE RECEIPT**  
(10CFR20.1906)

- Not regulated by DOT; regulated by the NRC (10CFR20.1906)
- Contamination monitoring of the external surface of LABELED packages unless only gas or special form
  - Must meet DOT contamination limits
- Radiation level monitoring of labeled packages unless  $\leq$  Type A quantity
- Contamination and radiation level monitoring of all packages if evidence of degradation (crushed, wet, damaged)
- Performed ASAP and within 3 hrs after receipt (or 3 hrs of start of business if received after normal working hours)
- Notification of final carrier and NRC\* if:
  - Removable surface contamination exceeds DOT contamination limits
  - External radiation levels exceed DOT radiation level limits (depend upon method of shipment; e.g., exclusive use)

*\*for agreement states, consult State regulations*

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**PACKAGE RECEIPT**  
(10CFR20.1906)

- Licensee must:
  - Have written procedures for package opening
  - Ensure procedures are followed
  - Licensees transferring special form sources in licensee-owned/operated vehicles to and from a work site are exempt from contamination monitoring requirements but not from the radiation level monitoring required to ensure that source is still properly shielded
- Type B quantities
  - Receive package when delivered or receive notification that package has arrived at carrier's terminal and take possession expeditiously

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**PRACTICAL APPLICATION**  
PUTTING IT ALL TOGETHER...

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### ANALYSIS

- Quantity (Limited, Type A, etc.)
  - Isotope
  - Form (Special vs. Normal)
  - Activity
- Package/Label
  - Radiation Levels (TI and Surface)
- Markings
  - Package (Specification packaging)
  - Radioactive
  - Reportable Quantity
  - Cargo Aircraft Only
  - Weight, etc.
- Shipping Papers (Dangerous Goods Declaration)
- Contamination Limits
- Quality Control

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### EXAMPLE 1: ISOTOPE/FORM

Isotope	Tc-99m
Form	Liquid
Activity	0.37 GBq (10 mCi)

Form (Special vs. Normal):

- Liquid ➔ Normal Form

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### EXAMPLE 1: ACTIVITY

Symbol of radionuclide	Element and atomic number	$A_1$ (TBq)	$A_2$ (Ci)	$A_3$ (TBq)	$A_4$ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Tc-99m		$1.0 \times 10^4$	$2.7 \times 10^2$	4.0	$1.1 \times 10^4$	$1.9 \times 10^4$	$5.3 \times 10^4$

  

	Tc-99m
$A_2$ (normal form)	$A_2 = 1.1 \text{E}02 \text{ Ci (110 Ci)}$ Limited Quantity (Liquids) = $10^4 A_2 = 11 \text{ mCi}$

Based on activity of 10 mCi, ACTIVITY can be classified as LIMITED QUANTITY!

However, need to take into account radiation levels when determining packaging!

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### EXAMPLE 1: RADIATION LEVELS/ PACKAGING/LABEL

Requirement for use of Excepted Packaging for Limited Quantities:

- Dose rate on surface of package must be  $\leq 0.5$  mrem/hr

	Tc-99m
Dose rate	TI = 0; Surface = 0.3 mrem/hr

Based on surface radiation level and Limited Quantity, can use EXCEPTED PACKAGING

EXCEPTED from LABELING requirement but NOT from markings, etc.

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### EXAMPLE 1: MARKINGS

Symbol	Hazardous materials description and proper shipping name	Hazard class or Division	Identification Number	PG	Label Codes
(1)	(2)	(3)	(4)	(5)	(6)
	Radioactive material, excepted package which manufactured from natural uranium or depleted uranium or natural thorium	7	UN2980	II	None
	Radioactive material, excepted package empty packaging	7	UN2980	Empty	
	Radioactive material, excepted package instruments or articles	7	UN2981	None	
	Radioactive material, excepted package limited quantity of material	7	UN2919	None	
	Radioactive material, low specific activity (LSA-I) non flammable or flammable	7	UN2912	II	
	Radioactive material, low specific activity (LSA-II) non flammable or flammable	7	UN3021	II	
	Radioactive material, low specific activity (LSA-II) non flammable or flammable	7	UN3022	II	
	Radioactive material, surface contaminated objects (SCO-I or SCO-II) non flammable or flammable	7	UN2913	II	
	Radioactive material, transported under special arrangement non flammable or flammable	7	UN2979	II	
	Radioactive material, transported under special arrangement, Radio	7	UN3024	II	
	Radioactive material, Type A package, Radio non-essential form	7	UN3027	II	
	Radioactive material, Type A package non-essential form, non flammable or flammable	7	UN2916	II	
	Radioactive material, Type A package, special form, non flammable or flammable	7	UN3032	II	
	Radioactive material, Type A package, special form, Radio	7	UN3033	II	
	Radioactive material, Type B(U) package, Radio	7	UN3025	II	
	Radioactive material, Type B(M) package non flammable or flammable	7	UN2917	II	
	Radioactive material, Type B(U) package, Radio	7	UN3026	II	
	Radioactive material, Type B(M) package non flammable or flammable	7	UN3016	II	
	Radioactive material, uranium hexafluoride non flammable or flammable	7	UN2978	II, III, R	
	Radioactive material, uranium hexafluoride, Radio	7	UN2977	II, III, R	

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### EXAMPLE 1: REPORTABLE QUANTITY

(1) — Radionuclide	(2) — Atomic Number	(3) — Reportable Quantity (RQ) Ci (TBq)
Technetium-99m	43	100 (3.7)

Tc-99m RQ = 100 Ci → Not RQ!

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### EXAMPLE 1: OVERVIEW

Isotope	Tc-99m
Activity	Limited Quantity
Package	Excepted Packaging (General Package Design)
Labels	NONE
Markings	UN2910 "Radioactive"
Shipping Papers	NONE (no secondary hazards)

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### EXAMPLE 1: CONTAMINATION LIMITS

Table 9 — Non-Fixed External Radioactive Contamination Limits for Packages

Contaminant	Maximum permissible limits		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
1. Beta and gamma emitters and low toxicity alpha emitters	4	10 <sup>-4</sup>	240
2. All other alpha emitting radionuclides	0.4	10 <sup>-5</sup>	24

- Area wiped = 300 cm<sup>2</sup>
- Assess wipes using NaI scintillation detector with an efficiency of 20% with NET result of 800 cpm
- Wipe efficiency of 10%
- Limit for Tc-99m = 240 dpm/cm<sup>2</sup>

$$dpm = \frac{800 \text{ cpm}}{300 \text{ cm}^2 \times 0.2 \text{ cpm/dpm} \times 0.1} = 133 \text{ dpm/cm}^2$$

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### EXAMPLE 1: PACKAGE




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### EXAMPLE 2: ISOTOPE/FORM

Isotope	Pu-238
Form	Solid, oxide (no certifications)
Activity	0.0224 Ci (22.4 mCi)

Is it Special or Normal Form??

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### EXAMPLE 2: ISOTOPE/FORM

Isotope	Pu-238
Form	Solid, oxide
Activity	0.0224 Ci (22.4 mCi)

Form:

- If unknown (or unsure if certified as Special Form)

→ NORMAL form

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### EXAMPLE 2: ACTIVITY

Isotope	Pu-238
Form	Solid, oxide (normal)
Activity	0.0224 Ci (22.4 mCi)

Symbol of radionuclide	Element and atomic number	A <sub>1</sub> (TBq)	A <sub>2</sub> (Ci)*	A <sub>3</sub> (TBq)	A <sub>4</sub> (Ci)*	Specific activity (TBq/g)	Specific activity (Ci/g)
Pu-238		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	6.3 × 10 <sup>-4</sup>	1.7 × 10 <sup>-1</sup>
Pu-239		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	2.3 × 10 <sup>-4</sup>	6.2 × 10 <sup>-1</sup>
Pu-240		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>2</sup>	0.4 × 10 <sup>-4</sup>	2.3 × 10 <sup>-1</sup>

Which "A" limit should be used?  
 What is the Quantity classification?  
 (LQ = 10<sup>-3</sup> A quantity)

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### EXAMPLE 2: ACTIVITY

Symbol of radionuclide	Element and atomic number	A <sub>1</sub> (TBq)	A <sub>2</sub> (Ci)	A <sub>1</sub> (TBq)	A <sub>2</sub> (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Pu-238		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>5</sup>	1.0 × 10 <sup>-1</sup>	2.7 × 10 <sup>-2</sup>	6.3 × 10 <sup>-6</sup>	1.7 × 10 <sup>-4</sup>
Pu-239		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>5</sup>	1.0 × 10 <sup>-1</sup>	2.7 × 10 <sup>-2</sup>	2.3 × 10 <sup>-6</sup>	6.2 × 10 <sup>-5</sup>
Pu-240		1.0 × 10 <sup>4</sup>	2.7 × 10 <sup>5</sup>	1.0 × 10 <sup>-1</sup>	2.7 × 10 <sup>-2</sup>	8.4 × 10 <sup>-6</sup>	2.3 × 10 <sup>-4</sup>

Pu-238	
A <sub>2</sub> (normal form)	A <sub>2</sub> = 2.7E-2 Ci (0.027 Ci) Limited Quantity = 10 <sup>3</sup> A <sub>2</sub> = 0.027 mCi

Based on the activities of 0.0224 Ci Pu-238, cannot be classified as LIMITED QUANTITY!

However, since ≤ A<sub>2</sub>, it is considered a TYPE A quantity

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### EXAMPLE 2: RADIATION LEVELS/ PACKAGING/LABEL

Pu-238 (Type A quantity)	
Dose rate	TI = 0.01 Surface = 0.4 mrem/hr

Transport Index	Maximum radiation level at any point on external surface	Label category
0	≤ 0.5 mrem/hr	NONE – Limited Quantity
0	≤ 0.5 mrem/hr	WHITE-I
> 0 and ≤ 1	> 0.5 mrem/hr and ≤ 50 mrem/hr	YELLOW-II
> 1 and < 10	> 50 mrem/hr and ≤ 200 mrem/hr	YELLOW-III
> 10 (and includes HRCG)	> 200 mrem/hr and ≤ 1,000 mrem/hr	YELLOW-III Exclusive Use

What packaging is required?  
What label(s) are required?

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### EXAMPLE 2: RADIATION LEVELS/ PACKAGING/LABEL

Pu-238	
Dose rate	TI = 0.01 Surface = 0.4 mrem/hr

Transport Index	Maximum radiation level at any point on external surface	Label category
0	≤ 0.5 mrem/hr	NONE – Limited Quantity
0	≤ 0.5 mrem/hr	WHITE-I
> 0 and ≤ 1	> 0.5 mrem/hr and ≤ 50 mrem/hr	YELLOW-II
> 1 and < 10	> 50 mrem/hr and ≤ 200 mrem/hr	YELLOW-III
> 10 (and includes HRCG)	> 200 mrem/hr and ≤ 1,000 mrem/hr	YELLOW-III Exclusive Use

Based on surface dose rate, package can be labeled as WHITE I and must be a TYPE A package (TI < 0.05 and is considered to be 0)

Not intended for use in or incident to medical diagnosis, treatment, research – CARGO AIRCRAFT ONLY

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### EXAMPLE 2: REPORTABLE QUANTITY

Isotope	Pu-238
Form	Solid, oxide
Activity	0.0224 Ci

(1) — Radionuclide	(2) — Atomic Number	(3) — Reportable Quantity (RQ) Ci (TBq)
Curium-244	96	0.01 (00037)
Curium-245	96	0.01 (00037)
Curium-246	96	0.01 (00037)
Californium-251	98	10 (37)
Francium-223	87	10 (37)
Plutonium-238	94	0.01 (00037)
Plutonium-239	94	0.01 (00037)
Plutonium-240	94	0.01 (00037)

Pu-238: RQ = 0.01 Ci → Reportable Quantity!

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### EXAMPLE 2: OVERVIEW

Isotope	Pu-238
Activity	Type A
Package	Type A
Labels	White I Cargo Aircraft Only
Markings	UN2915 SQ Type A Package
Shipping Papers	Required Emergency Response Information

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### EXAMPLE 2: SHIPPING PAPERS

- Passenger vs. cargo aircraft:
  - Not intended for use in, or incident to research, medical diagnosis or treatment
- Dimensions of package
- Activities must be in SI units
- No TI (White I)

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### EXAMPLE 2: CONTAMINATION LIMITS

Table 9 — Non-Fixed External Radioactive Contamination Limits for Packages

Contaminant	Maximum permissible limit		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
1. Beta and gamma emitters and low toxicity alpha emitters	4	10 <sup>-4</sup>	240
2. All other alpha emitting radionuclides	0.4	10 <sup>-5</sup>	24

- Area wiped = 300 cm<sup>2</sup>
- Assess wipes using LSC with an efficiency of 20% with NET result of 20 cpm
- Wipe efficiency of 10%
- Limit for Pu-238 = 24 dpm/cm<sup>2</sup>

$$dpm = \frac{20 \text{ cpm}}{300 \text{ cm}^2 \times 0.2 \text{ cpm/dpm} \times 0.1} = 3.3 \text{ dpm/cm}^2$$

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### EXAMPLE 2: PACKAGE




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### EXAMPLE 3: ISOTOPE/FORM

Isotope	Ge-68
Form	Solid polymer (no certifications)
Activity	174 MBq (4.7 mCi)

Is it Special or Normal Form???

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### EXAMPLE 3: ISOTOPE/FORM

Isotope	Ge-68
Form	Solid polymer
Activity	174 MBq (4.7 mCi)

Form:  
Probably Special Form, but I don't know for sure!  
If unknown (or unsure if certified as Special Form)

→ NORMAL form

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### EXAMPLE 3: ACTIVITY

Isotope	Ge-68
Form	Solid polymer (normal)
Activity	174 MBq (4.7 mCi)

Symbol of radionuclide	Element and atomic number	A <sub>1</sub> (TBq)				Specific activity	
		A <sub>1</sub> (TBq)	A <sub>1</sub> (Ci)	A <sub>2</sub> (TBq)	A <sub>2</sub> (Ci)	(TBq/g)	(Ci/g)
Ge-68 (a)	Germanium (32)	5.0 × 10 <sup>1</sup>	1.4 × 10 <sup>2</sup>	5.0 × 10 <sup>2</sup>	1.4 × 10 <sup>3</sup>	2.6 × 10 <sup>2</sup>	7.1 × 10 <sup>2</sup>

A<sub>1</sub> and/or A<sub>2</sub> values for these parent radionuclides include contributions from daughter radionuclides with half-lives less than 10 days as listed in footnote (a) to Table 2 in the "NRC Regulations for the Safe Transport of Radioactive Material, 49 CFR 171.7 of this subchapter).

Which "A" limit should be used?  
What is the Quantity classification?  
(LQ = 10<sup>-3</sup> A quantity)

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### EXAMPLE 3: ACTIVITY

Symbol of radionuclide	Element and atomic number	A <sub>1</sub> (TBq)				Specific activity	
		A <sub>1</sub> (TBq)	A <sub>1</sub> (Ci)	A <sub>2</sub> (TBq)	A <sub>2</sub> (Ci)	(TBq/g)	(Ci/g)
Ge-68 (a)	Germanium (32)	5.0 × 10 <sup>1</sup>	1.4 × 10 <sup>2</sup>	5.0 × 10 <sup>2</sup>	1.4 × 10 <sup>3</sup>	2.6 × 10 <sup>2</sup>	7.1 × 10 <sup>2</sup>

A<sub>1</sub> and/or A<sub>2</sub> values for these parent radionuclides include contributions from daughter radionuclides with half-lives less than 10 days as listed in footnote (a) to Table 2 in the "NRC Regulations for the Safe Transport of Radioactive Material, 49 CFR 171.7 of this subchapter).

	Ge-68
Appropriate A <sub>2</sub>	A <sub>2</sub> = 1,460 Ci (14 Ci) Limited = 10 <sup>-3</sup> A <sub>2</sub> = 14 mCi

Based on activity of 4.7 mCi, quantity can be classified as LIMITED QUANTITY!  
BUT remember the importance of radiation levels...

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### EXAMPLE 3: OVERVIEW

Isotope	Ge-68
Activity	Limited Quantity
Package	Type A (because of radiation levels)
Label	Yellow II
Markings	UN2915 Type A package
Shipping Papers	Required Emergency Response Information

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### EXAMPLE 3: SHIPPING PAPERS

- Passenger vs. cargo aircraft:
  - Intended for use in, or incident to research, medical diagnosis or treatment
- Dimensions of package
- Activities must be in SI units
- TI required (Yellow II)

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### EXAMPLE 3: CONTAMINATION LIMITS

Table 3 — Non-Fixed External Radioactive Contamination Limits for Packages

Contaminant	Maximum permissible limits		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
1 Beta and gamma emitters and low toxicity alpha emitters	4	10	240
2 All other alpha emitting radionuclides	0.4	10	24

- Area wiped = 300 cm<sup>2</sup>
- Assess wipes using pancake GM with an efficiency of 25% with NET result of 150 cpm
- Wipe efficiency of 10%
- Limit for Ge-68 = 240 dpm/cm<sup>2</sup>

$$dpm = \frac{150 \text{ cpm}}{300 \text{ cm}^2 \times 0.25 \text{ cpm/dpm} \times 0.1} = 20 \text{ dpm/cm}^2$$

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EXAMPLE 3: PACKAGE




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EXAMPLE 4: ISOTOPE/FORM

Isotope	Ir-192 (HDR)
Form	Sealed source (Certification)
Activity	370 GBq (10 Ci)

Is it Special or Normal Form??

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EXAMPLE 4: ISOTOPE/FORM

Isotope	Ir-192 (HDR)
Form	Sealed source (Certification)
Activity	370 GBq (10 Ci)

Certification is provided = Special Form

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### EXAMPLE 4: REPORTABLE QUANTITY

Isotope	Ir-192 (HDR)
Form	Sealed source
Activity	370 GBq (10 Ci)

(1) — Radionuclide	(2) — Atomic Number	(3) — Reportable Quantity (RQ) Ci (TBq)
Caesium-244	96	0.01 (0.0037)
Caesium-245	96	0.01 (0.0037)
Caesium-246	96	0.01 (0.0037)
Germanium-68	32	10 (37)
Iridium-192	77	10 (37)
Plutonium-238	94	0.01 (0.0037)
Plutonium-239	94	0.01 (0.0037)
Plutonium-240	94	0.01 (0.0037)

Is it a Reportable Quantity?

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### EXAMPLE 4: REPORTABLE QUANTITY

Isotope	Ir-192 (HDR)
Form	Sealed source
Activity	370 GBq (10 Ci)

(1) — Radionuclide	(2) — Atomic Number	(3) — Reportable Quantity (RQ) Ci (TBq)
Caesium-244	96	0.01 (0.0037)
Caesium-245	96	0.01 (0.0037)
Caesium-246	96	0.01 (0.0037)
Germanium-68	32	10 (37)
Iridium-192	77	10 (37)
Plutonium-238	94	0.01 (0.0037)
Plutonium-239	94	0.01 (0.0037)
Plutonium-240	94	0.01 (0.0037)

Ir-192 RQ = 10 Ci → RQ!

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### EXAMPLE 4: MARKINGS

- UN 3332
- RQ
- Weight (due to shielding > 110 lb)




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### EXAMPLE 4: OVERVIEW

Isotope	Ir-192
Activity	Type A
Package	Type A
Labels	Yellow III Cargo Aircraft Only
Markings	UN3332; RQ HEAVY with weight Type A package
Shipping Papers	Required Emergency Response Information

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### EXAMPLE 4: SHIPPING PAPERS

- Passenger vs. cargo aircraft:
  - Intended for use in, or incident to research, medical diagnosis or treatment
  - HOWEVER: must be transported via cargo aircraft (TI > 3)
- Dimensions of package
- Activities must be in SI units
- TI required (Yellow III)

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### EXAMPLE 4: CONTAMINATION LIMITS

**Table 9 — Non-Fixed External Radioactive Contamination Limits for Packages**

Contaminant	Maximum permissible limits		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
1 Beta and gamma emitters and low toxicity alpha emitters	4	10 <sup>-4</sup>	240
2 All other alpha emitting radionuclides	0.4	10 <sup>-5</sup>	24

- Area wiped = 300 cm<sup>2</sup>
- Assess wipes using pancake GM with an efficiency of 15% with NET result of 200 cpm
- Wipe efficiency of 10%
- Limit for Ir-192 = 240 dpm/cm<sup>2</sup>

$$dpm = \frac{200 \text{ cpm}}{300 \text{ cm}^2 \times 0.15 \text{ cpm/dpm} \times 0.1} = 44.4 \text{ dpm/cm}^2$$


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### EXAMPLE 4: PACKAGE



USA DOT 7A TYPE A  
RADIOACTIVE MATERIAL  
TYPE A PACKAGE  
SPECIAL FORM  
UN 3332 RQ



Radioactive III label courtesy of JJ Keller; Heavy parcel label courtesy of ebay.co.uk

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### CONCLUSION

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### LEARNING OBJECTIVES

- Review NRC and DOT regulations applicable to the following:
  - Training and certification of personnel who package/transport radioactive material
  - Classification of radioactive material
    - Special vs. Normal form
    - Quantities
  - Packaging of radioactive material
  - Labeling and marking of radioactive material packages
  - Transportation of radioactive material
  - Radiation level limits and contamination control
  - Receipt and opening of radioactive material packages

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### “WORDS OF WISDOM”

- FedEx is a common way to ship radioactive material packages (Excepted, Type A)
- Follow IATA
- Dangerous Goods Hotline for FedEx
  - Packages may be returned for “no reason”
  - Call and ask!
- Only need two copies of Dangerous Goods Declaration with red border (the rest can be copies)
- Keep up with the regulations

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### AND MORE...

- If you have your own transportation program, consider various methods
  - e.g., LSA, SCO, LQ
- Check the regs!!!
- Look for loopholes for packaging, surveys, physician exemptions, etc.

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### FINALLY...

- Keep packages for items received (e.g., sealed sources) if they will be returned
  - If returning source to vendor, they usually have packaging (Type A) available for purchase
- Double-check EVERYTHING!
- Make sure the emergency phone will be answered during the entire shipping period
- If you need to ship overseas, hire a shipper
- Fill-in Dangerous Goods Declaration forms available on-line (use one with columns!)
- Set up a training program and keep records
- Consult!

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## REFERENCES

- Code of Federal Regulations
  - Title 10
  - Title 49
  - Title 71
- "Regulations for the Safe Transport of Radioactive Material" 2018 Edition; IAEA Specific Safety Requirements No. SSR-6 (Rev. 1)
- "Transportation of Radioactive Material" Reactor Concepts Manual, USNRC Training Center, Rev 0703
- [www.ecfr.gov](http://www.ecfr.gov)
- [www.phmsa.dot.gov](http://www.phmsa.dot.gov)
- <https://www.fedex.com/en-us/service-guide/dangerous-goods-hazardous-materials.html>
  - Resources, regulatory updates, training
  - Dangerous goods hotline – 1-800-463-3339
  - IATA variations (exceptions to IATA dangerous goods regulations)

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